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# An Ultra-efficient Nonlinear Platform: AlGaAs-on-Insulator

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**Abstract**— The combination of nonlinear and integrated photonics enables applications including optical signal processing, multi-wavelength lasers, metrology, spectroscopy, and quantum information science. Silicon-on-insulator (SOI) has emerged as a promising platform [1, 2] due to its high material nonlinearity and its compatibility with the CMOS industry. However, silicon suffers two-photon absorption (TPA) in the telecommunication wavelength band around  $1.55\ \mu\text{m}$ , which hampers its applications. Different platforms have been proposed to avoid TPA in the telecom wavelength range such as  $\text{Si}_3\text{N}_4$  and Hydrex [3]. Though tremendous technological work in those platforms have greatly improved device performances, the relatively low intrinsic material nonlinearities of those materials limit device performances concerning efficiency. Therefore, an integrated nonlinear platform that combines a high material nonlinearity, a high-index contrast as SOI, and low linear and nonlinear losses is highly desired.

Aluminium gallium arsenide (AlGaAs) was early identified as a promising candidate and even nominated as “the silicon of nonlinear optical material” [4] when operated just below half its bandgap energy. It offers a nonlinear index ( $n_2$ ) on the order of  $10^{-17}\ \text{W/m}^2$  and a high refractive index ( $n \approx 3.3$ ), a large transparency window (from near- to mid-infrared), and the ability to engineer the material bandgap to mitigate TPA [5]. In this presentation, we introduce AlGaAs-on-insulator (AlGaAsOI) platform which combines both strong nonlinear light-matter interaction induced by high-index contrast layout and the potential to fabricate complex designs similar to what is done in silicon-on-insulator photonics. We demonstrate low loss ( $\sim 1.4\ \text{dB/cm}$ ) nanowaveguides with an ultra-high nonlinear coefficient ( $\sim 660\ \text{W}^{-1}\text{m}^{-1}$ ) and microring resonators with quality factors on the order of  $10^5$  [6]. The large effective nonlinearity of such platform enables efficient nonlinear processes such as high-speed optical signal processing [7], supercontinuum generation, and Kerr frequency comb generation [8]. Moreover, the required operation power for signal generation processes such as optical parametric oscillation in the AlGaAsOI platform is well within the range of standard on-chip light sources. In line with the fast-growing hybrid integration trend to combine different materials in multiple levels on a single CMOS compatible chip, the AlGaAsOI platform is very promising for realizing a compact fully-integrated multi-wavelength light source for high bandwidth optical interconnects.

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